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LOGICAL OPERATION OF SET INTERSECTION FOR IMAGES IN OPTICAL ECHO HOLOGRAPHY

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We use a stimulated echo hologram to consider performing logical operations on sets represented in the form of images. We show that a stimulated echo hologram can be used to perform the logical operation of set intersection.

Keywords: *echo holography, wave front, standing waves, logical operation with sets.*

Development of coherent optics and holography began with the appearance of lasers. Since then, realization of a number of computational operations has become possible using optical methods. Optical methods for data processing make it possible to simultaneously work with large volumes of data at high processing speed and to perform a variety of integrated operations on two-dimensional data sets. By utilizing different combinations of optical coherent radiation parameters (amplitude, frequency, phase, polarization, resolvable elements in the image (pixels)), data transfer and processing can be done in high volumes at high speed.

In this paper, we consider the echo holographic method for data processing, where logical operations are performed with images using optical processors. There are two types of processors: logical processors, carrying out a strictly defined set of logical operations; and logical inference systems, usually called fuzzy associative memory, which carry out complex operations in the class of fuzzy associations.

For the first type of processors, various architectures have been suggested which use array type radiation sources and detectors such as linear arrays [1], two-dimensional arrays [2–4] and more complicated schemes based on them [5–9], also combined with an image memory system [10], an image recognition system [11], and morphological image processing [12]. The second type of processors generally perform logical inference [12–19]. Thus in [17], a spatially-invariant joint transform correlator is used for independent calculation of the membership function for input associations with each reference value. Fourier optics is used to generate a set of values for the membership function which correspond to the result of application of each logical rule to the input value [18, 19].

The first optical processors were developed in the 1980s. They used special elements where light should control light, while the logical operations were carried out as a result of interaction between light and matter. In 1990, Bell Labs developed a prototype for an optical device where logic and arithmetic operations were carried out at very high speed. In 2003, Lenslet Ltd. built the EnLight256 optical processor, in which operations were performed due to the possibilities for controlling light flux, and the resulting speed was $8 \cdot 10^{12}$ operations/second [20].

Today, there is interest in developing processors which are multifunctional devices enabling real-time integrated signal processing. They are based on the use of echo holography [21]. In contrast to the conventional method for recording holograms, echo holograms (EH) are not formed by interference between the object and reference fields but rather as a result of interference between atomic states. Superimposed states appear during the transient process and they exist until relaxation of the nonequilibrium atomic polarization (formed in response to coherent radiation) is complete. Thus recording dynamic echo holograms under conditions of coherent nonlinear interaction of the object and reference laser pulses with the resonant medium makes it possible to store and reconstruct information about dynamic processes associated with a change in the states in space and time. Such holograms contain information about the spatial and temporal structure of the object wave field. Especially attractive is the ability of echo holograms to reconstruct or invert wavefronts and the temporal shape

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